

Our Ref.: 2380-291
P14219US

U.S. PATENT APPLICATION

Inventor(s): Staffan ANDERSSON
Mikael AGNEVIK

Invention: CONNECTED HANDLING IN SRNC RELOCATION

***NIXON & VANDERHYE P.C.
ATTORNEYS AT LAW
1100 NORTH GLEBE ROAD
8TH FLOOR
ARLINGTON, VIRGINIA 22201-4714
(703) 816-4000
Facsimile (703) 816-4100***

SPECIFICATION

CONNECTION HANDLING IN SRNC RELOCATION

BACKGROUND

This application is related to simultaneously-filed and commonly assigned United States Patent Application Serial Number __/__, (attorney docket: 2380-187), entitled "Binding Information For Telecommunications Network", which is incorporated herein by reference in its entirety. This application also claims the benefit and priority of commonly assigned United States Provisional Patent Application Serial Number 60/257,116, filed December 22, 2000, entitled "Binding Information For Telecommunications Network", which is incorporated herein by reference in its entirety.

1. FIELD OF THE INVENTION

The present invention pertains to wireless telecommunications, and particularly to moveover or relocation of a serving radio network control node in a radio access network.

2. RELATED ART AND OTHER CONSIDERATIONS

In a typical cellular radio system, mobile user equipment units (UEs) communicate via a radio access network (RAN) to one or more core networks. The user equipment units (UEs) can be mobile stations such as mobile telephones ("cellular" telephones) and laptops with mobile termination, and thus can be, for example, portable, pocket, hand-held, computer-included, or car-mounted mobile devices which communicate voice and/or data with radio access network.

The radio access network (RAN) covers a geographical area which is divided into cell areas, with each cell area being served by a base station. A cell is a geographical area where radio coverage is provided by the radio base station equipment at a base station site. Each cell is identified, typically by a unique identity, which is

broadcast in the cell. The base stations communicate over the air interface (e.g., radio frequencies) with the user equipment units (UE) within range of the base stations. In the radio access network, several base stations are typically connected (e.g., by landlines or microwave) to a radio network controller (RNC). The radio network controller, also sometimes termed a base station controller (BSC), supervises and coordinates various activities of the plural base stations connected thereto. The radio network controllers are typically connected to one or more core networks.

One example of a radio access network is the Universal Mobile Telecommunications (UMTS) Terrestrial Radio Access Network (UTRAN). The UTRAN is a third generation system which is in some respects builds upon the radio access technology known as Global System for Mobile communications (GSM) developed in Europe. UTRAN is essentially a wideband code division multiple access (W-CDMA) system.

As those skilled in the art appreciate, in W-CDMA technology a common frequency band allows simultaneous communication between a user equipment unit (UE) and plural base stations. Signals occupying the common frequency band are discriminated at the receiving station through spread spectrum CDMA waveform properties based on the use of a high speed code, such as a pseudo-noise (PN) code. These high speed PN codes are used to modulate signals transmitted from the base stations and the user equipment units (UEs). Transmitter stations using different PN codes (or a PN code offset in time) produce signals that can be separately demodulated at a receiving station. The high speed PN modulation also allows the receiving station to advantageously generate a received signal from a single transmitting station by combining several distinct propagation paths of the transmitted signal. In CDMA, therefore, a user equipment unit (UE) need not switch frequency when handoff of a connection is made from one cell to another. As a result, a destination cell can support a connection to a user equipment unit (UE) at the same time the origination cell continues to service the connection. Since the user equipment unit (UE) is always communicating through at least one cell during handover, there is no disruption to the call. Hence, the term "soft handover." In contrast to hard handover, soft handover is a "make-before-break" switching operation.

The Universal Mobile Telecommunications (UMTS) Terrestrial Radio Access Network (UTRAN) accommodates both circuit switched and packet switched connections. In this regard, in UTRAN the circuit switched connections involve a radio network controller (RNC) communicating with a mobile switching center (MSC), which in turn is connected to a connection-oriented, external core network, which may be (for example) the Public Switched Telephone Network (PSTN) and/or the Integrated Services Digital Network (ISDN). On the other hand, in UTRAN the packet switched connections involve the radio network controller communicating with a Serving GPRS Support Node (SGSN) which in turn is connected through a backbone network and a Gateway GPRS support node (GGSN) to packet-switched networks (e.g., the Internet, X.25 external networks).

For the UMTS R99 standard as specified by the Third Generation Partnership Project (3GPP), AAL2/ATM was selected as the user data transport in the wideband CDMA (WCDMB) radio access network (e.g., the UTRAN). Asynchronous Transfer Mode (ATM) technology (ATM) is a packet-oriented transfer mode which uses asynchronous time division multiplexing techniques. Packets are called cells and have a fixed size. An ATM cell consists of 53 octets, five of which form a header and forty eight of which constitute a "payload" or information portion of the cell. The header of the ATM cell includes two quantities which are used to identify a connection in an ATM network over which the cell is to travel, particularly the VPI (Virtual Path Identifier) and VCI (Virtual Channel Identifier). In general, the virtual path is a principal path defined between two switching nodes of the network; the virtual channel is one specific connection on the respective principal path.

A protocol reference model has been developed for illustrating layering of ATM. The protocol reference model layers include (from lower to higher layers) a physical layer (including both a physical medium sublayer and a transmission convergence sublayer), an ATM layer, and an ATM adaptation layer (AAL), and higher layers. The basic purpose of the AAL layer is to isolate the higher layers from specific characteristics of the ATM layer by mapping the higher-layer protocol data units (PDU) into the information field of the ATM cell and vice versa.

There are several differing AAL types or categories, including AAL0, AAL1, AAL2, AAL3/4, and AAL5. AAL2 is a standard defined by ITU recommendation

I.363.2. An AAL2 packet comprises a three octet packet header, as well as a packet payload. The AAL2 packet header includes an eight bit channel identifier (CID), a six bit length indicator (LI), a five bit User-to-User indicator (UUI), and five bits of header error control (HEC). The AAL2 packet payload, which carries user data, can vary from one to forty-five octets. Several AAL2 packets can be multiplexed on an ATM virtual channel (ATM VC).

The radio network controller (RNC) controls the UTRAN. In fulfilling its control role, the RNC manages resources of the UTRAN. Such resources managed by the RNC include (among others) the downlink (DL) power transmitted by the base stations; the uplink (UL) interference perceived by the base stations; and the hardware situated at the base stations.

There are several interfaces of interest in the UTRAN. The interface between the radio network controllers (RNCs) and the core network(s) is termed the "Iu" interface. The interface between a radio network controller (RNC) and its base stations (BSs) is termed the "Iub" interface. The interface between the user equipment unit (UE) and the base stations is known as the "air interface" or the "radio interface" or "Uu interface". In some instances, a radio connection involves both a Serving or Source RNC (SRNC) and a target or drift RNC (DRNC), with the SRNC controlling the radio connection but with one or more radio links of the radio connection being handling by the DRNC. An Inter-RNC transport link can be utilized for the transport of control and data signals between Source RNC and a Drift or Target RNC, and can be either a direct link or a logical link as described, for example, in International Application Number PCT/US94/12419 (International Publication Number WO 95/15665). An interface between radio network controllers (e.g., between a Serving RNC [SRNC] and a Drift RNC [DRNC]) is termed the "Iur" interface.

Those skilled in the art appreciate that, with respect to a certain RAN-UE connection, an RNC can either have the role of a serving RNC (SRNC) or the role of a drift RNC (DRNC). If an RNC is a serving RNC (SRNC), the RNC is in charge of the radio connection with the user equipment unit (UE), e.g., it has full control of the radio connection within the radio access network (RAN). A serving RNC (SRNC) is connected to the core network. On the other hand, if an RNC is a drift RNC (DRNC), its supports the serving RNC (SRNC) by supplying radio resources (within the cells

controlled by the drift RNC (DRNC)) needed for the radio connection with the user equipment unit (UE). A system which includes the drift radio network controller (DRNC) and the base stations controlled over the Iub Interface by the drift radio network controller (DRNC) is herein referenced as a DRNC subsystem or DRNS.

When a radio connection between the radio access network (RAN) and user equipment unit (UE) is being established, the radio access network (RAN) decides which RNC is to be the serving RNC (SRNC) and, if needed, which RNC is to be a drift RNC (DRNC). Normally, the RNC that controls the cell where the user equipment unit (UE) is located when the radio connection is first established is initially selected as the serving RNC (SRNC). As the user equipment unit (UE) moves, the radio connection is maintained even though the user equipment unit (UE) may move into a new cell, possibly even a new cell controlled by another RNC. That other RNC becomes a drift RNCs (DRNC) for RAN-UE connection. An RNC is said to be the Controlling RNC (CRNC) for the base stations connected to it by an Iub interface. This CRNC role is not UE specific. The CRNC is, among other things, responsible for handling radio resource management for the cells in the base stations connected to it by the Iub interface.

In certain situations it is advantageous to transfer control of a particular UE connection from one RNC to another RNC. Such a transfer of control of the UE connection from one RNC to another RNC has been referred to as soft RNC handover, SRNC moveover, and SRNC relocation. A relocate function/procedure is provided to effect this transfer of control. This is a general function/procedure covering UMTS internal relocations (e.g., relocation of SRNC within the UMTS) as well as relocations to other systems (e.g., from UMTS to GSM, for example). SRNC relocation is described in various references, including the following example commonly assigned patent applications (all of which are incorporated herein by reference):

(1) United States Patent Application Serial No. 09/035,821 filed March 6, 1998, entitled "Telecommunications Inter-Exchange Measurement Transfer";

(2) United States Patent Application Serial No. 09/035,788 filed March 6, 1998, entitled "Telecommunications Inter-Exchange Congestion Control";

(3) United States Patent Application Serial No. 08/979,866 filed November 26, 1997, entitled "Multistage Diversity Handling For CDMA Mobile Telecommunications";

(4) United States Patent Application Serial No. 08/980,013 filed November 26, 1997, entitled "Diversity Handling Moveover For CDMA Mobile Telecommunications";

(5) United States Patent Application Serial No. 09/732,877 filed December 11, 2000, entitled "Control Node Handover In Radio Access Network";

(6) United States Patent Application Serial No. 09/543,536 filed April 5, 2000, entitled "Relocation of Serving Radio Network Controller With Signaling of Linking of Dedicated Transport Channels".

SRNC relocation is intended to make more efficient use of the transmission network. Once the former SRNC is not needed, the connection to the core network is moved and the connection between the two RNCs (the former SRNC and the former DRNC over the Inter-RNC link) is disconnected.

An important function in the new CDMA networks is the soft handover function (briefly described above). Implementation of soft handover is facilitated by a diversity handling (DHO) unit or device. The DHO is situated at the SRNC handling the connection to a certain user equipment unit (UE). In the uplink from the user equipment unit (UE), the DHO combines the user data from two or more legs from different base stations, choosing the best data for forwarding on to the other party involved in the connection. In the downlink, the DHO splits the data into two or more legs for transmission to the different base stations. A DHO is always involved in a connection which has soft handover capability.

As mentioned above, a DHO is allocated in the SRNC. Fig. 1 shows such a SRNC 326₁ connected to a core network and controlling radio base stations RBS 328₁₋₁ through RBS₂₋₁. The SRNC 326₁ has a DHO 327₁, as well as an extension terminal ET 325₁ through which SRNC 326₁ interfaces with Inter-RNC link 329. Fig. 1 further shows a DRNC 326₂, having an extension terminal ET 325₂ for interfacing with the Inter-RNC link, and controlling radio base stations RBS 328₂₋₁ through RBS₂₋₂. Fig. 1

shows a situation having a call involving user equipment unit (UE) 330 routed over DRNC 326₂, with a DHO 327₂ also being allocated at the DRNC 326₂ just in case SRNC relocation should occur (e.g., pending SRNC relocation). But this allocation of an extra DHO exacts network resources, and can introduce an undesired delay.

5 Rather than a situation involving two allocated DHOs such as that shown in Fig. 1, it is more preferable that only one DHO be allocated at a time for a given connection, with that one DHO being at the SRNC. To cater to this preference, it is conceivable to wait to allocate a new DHO 327₂ at a new SRNC 326₂ until the SRNC relocation actually occurs as shown in Fig. 2, and to set up a new connection from the DHO to the
10 RBS after disconnecting the old connection. The connections are then always setup end-to-end by means of AAL2 signaling. However, the applicable standards require that the connection to the RBS from the DRNC always be kept.

What is needed, therefore, and an object of the present invention, is a SRNC relocation technique which involves allocation of only one diversity handling unit (DHO) at a time, but which does not change the connection from the new SRNC to the
15 radio base station (RBS).

BRIEF SUMMARY OF THE INVENTION

In a radio access network of a telecommunications system, an end-to-end signaling protocol is utilized to establish at least a node-transcendent one of plural
20 distinct connection or link segments comprising a radio connection involving a user equipment unit. The plural distinct connection segments extend in series between a device in a first radio network control node and a device in a base station controlled by a second radio network control node. The first radio network control node serves as a serving radio network control (SRNC) node and the second radio network control
25 serves as a drift radio network control (DRNC) node for the radio connection with the user equipment unit. An example end-to-end signaling protocol is AAL2.

Provision of the plural distinct connection segments is advantageous when performing a SRNC relocation procedure to make the second radio network control node serve as the SRNC for the radio connection involving the user equipment unit.
30 For example, after performance of the SRNC relocation procedure, a retained one of the

plural distinct connection segments can still be utilized, e.g., a segment extending between the base station controlled by the second radio network control node and a device at the second radio network control node. The retained one of the connection segments can either be utilized in series with a post-relocation connection segment to establish a path between the device at the base station controlled by the second radio network control node and a diversity handover unit at the second radio network control node, or have its connection point moved to the diversity handover unit at the second radio network control node.

Disclosed modes include a three connection segment mode and a two connection segment mode. In the three connection segment mode, a first of the plural distinct connection segments is established between a first connection point at the second radio network control node and the base station controlled by the second radio network control node. Another (second) of the plural distinct connection segments is established between the first connection point at the second radio network control node and a second connection point at the second radio network control node. Yet another (third) of the plural distinct connection segments is established between the second connection point at the second radio network control node and the device at the first radio network control node. The first connection point and the second connection point at the second radio network control node can be, for example, a first connection point and a second connection point (e.g., in/at a first extension terminal and a second extension terminal, respectively). The first connection segment extends through a switch at the second radio network control node

In the three connection segment mode, upon performing a SRNC relocation procedure to make the second radio network control node serve as the SRNC for the radio connection involving the user equipment unit; the first connection segment can be retained to comprise the radio connection with the user equipment unit. Moreover, subsequent to performance of the SRNC relocation procedure, the first connection segment can be utilized in series with a post-relocation connection segment to establish a path between the base station controlled by the second radio network control node and a diversity handover unit at the second radio network control node.

In the two connection segment mode, a first (retainable) of the plural distinct connection segments is established between a connection point at the second radio

network control node and the base station controlled by the second radio network control node. Another (second) of the plural distinct connection segments is established between the connection point at the second radio network control node and the device at the first radio network control node. The connection point at the second
 5 radio network control node can be a connection point (e.g., extension terminal) situated between a switch of the second radio network control node and a link to the first radio network control node.

In the two connection segment mode, upon performing a SRNC relocation procedure to make the second radio network control node serve as the SRNC for the
 10 radio connection involving the user equipment unit; an endpoint of the first (retainable) one of the plural distinct connection segments can be moved to a diversity handover unit at the second radio network control node, thereby still keeping the first connection segment after the SRNC relocation.

In one of its aspects, the present invention utilizes binding information to
 15 accommodate employment of the multiple connection segments such as described in the three connection segment mode and the two connection segment mode. In this regard, the node-transcending one of the plural distinct connection segments has a connection point at a given node, the given node being one of the first radio network control node, the second radio network control node, and the base station. The given
 20 node has a call control process in a call layer which is separated from a connection control process in a connection layer. In accordance with this aspect of the invention, the call layer control process obtains a binding reference to represent the connection point. In one implementation of this aspect, the binding reference (such as, for example, a Served User Generated Reference [SUGR]) is in a predetermined range
 25 which is reserved for setting up AAL2 connections (e.g., connection segments) to connection points. In another implementation, the binding reference is associated in a table with a predetermined value which denotes a connection point value. The binding reference can be obtained either from the connection layer or from the call layer.

BRIEF DESCRIPTION OF THE DRAWINGS

30 The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as

illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Fig. 1 is a schematic view of portions of a telecommunications system illustrating a first way of performing a SRNC relocation procedure.

Fig. 2 is a schematic view of portions of a telecommunications system illustrating a second way of performing a SRNC relocation procedure.

Fig. 3 is a schematic view of portions of an example, representative telecommunications system in which inventive modes of establishing radio connections and performing SRNC relocation can be implemented.

Fig. 4A - Fig. 4C are schematic views illustrating example stages of a first example mode of establishing radio connections and performing SRNC relocation according to the present invention.

Fig. 5A - Fig. 5D are schematic views illustrating example stages of a second example mode of establishing radio connections and performing SRNC relocation according to the present invention.

Fig. 6 is a diagrammatic view showing stages of a call layer and connection layer binding technique for the first example mode of the invention.

Fig. 7 is a diagrammatic view showing stages of a call layer and connection layer binding technique for the second example mode of the invention.

Fig. 8 is a diagrammatic view showing a call layer and connection layer binding technique for the first mode of the invention during an SRNC relocation procedure.

Fig. 9 is a diagrammatic view showing a call layer and connection layer binding technique for the second mode of the invention during an SRNC relocation procedure.

Fig. 10 is a schematic view of an example, representative RNC node which can be utilized with an implementation of the invention.

Fig. 11 is a schematic view of an example, representative base station node which can be utilized with an implementation of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail.

The present invention is described in the non-limiting, example context of a universal mobile telecommunications (UMTS) 10 shown in Fig. 3. A representative, connection-oriented, external core network, shown as a cloud 12 may be for example the Public Switched Telephone Network (PSTN) and/or the Integrated Services Digital Network (ISDN). A representative, connectionless-oriented external core network shown as a cloud 14, may be for example the Internet. Both core networks are coupled to corresponding service nodes 16. The PSTN/ISDN connection-oriented network 12 is connected to a connection-oriented service node shown as a Mobile Switching Center (MSC) node 18 that provides circuit-switched services. The Internet connectionless-oriented network 14 is connected to a General Packet Radio Service (GPRS) node 20 tailored to provide packet-switched type services which is sometimes referred to as the serving GPRS service node (SGSN). Those skilled in the art will appreciate that the functions may be implemented using individual hardware circuits, using software functioning in conjunction with a suitably programmed digital microprocessor or general purpose computer, using an application specific integrated circuit (ASIC), and/or using one or more digital signal processors (DSPs).

Each of the core network service nodes 18 and 20 connects to a UMTS Terrestrial Radio Access Network (UTRAN) 24 over a radio access network (RAN) interface referred to as the Iu interface. UTRAN 24 includes one or more radio network controllers (RNCs) 26. For sake of simplicity, the UTRAN 24 of Fig. 3 is shown with only two RNC nodes, particularly RNC 26₁ and RNC 26₂. Each RNC 26 is connected

to a plurality of base stations (BS) 28. For example, and again for sake of simplicity, two base station nodes are shown connected to each RNC 26. In this regard, RNC 26₁ serves base station 28_{1,1} and base station 28_{1,2}, while RNC 26₂ serves base station 28_{2,1} and base station 28_{2,2}. It will be appreciated that a different number of base stations can be served by each RNC, and that RNCs need not serve the same number of base stations. Moreover, Fig. 1 shows that an RNC can be connected over an Iur interface to one or more other RNCs in the UTRAN 24.

In the illustrated embodiments, for sake of simplicity each base station 28 is shown as serving one cell. Each cell is represented by a circle which surrounds the respective base station. It will be appreciated by those skilled in the art, however, that a base station may serve to communicate across the air interface for more than one cell. For example, two cells may utilize resources situated at the same base station site.

A user equipment unit (UE), such as user equipment unit (UE) 30 shown in Fig. 3, communicates with one or more cells or one or more base stations (BS) 28 over a radio or air interface 32. Each of the radio interface 32, the Iu interface, the Iub interface, and the Iur interface are shown by dash-dotted lines in Fig. 3.

Preferably, radio access is based upon wideband, Code Division Multiple Access (WCDMA) with individual radio channels allocated using CDMA spreading codes. Of course, other access methods may be employed. WCDMA provides wide bandwidth for multimedia services and other high transmission rate demands as well as robust features like diversity handoff and RAKE receivers to ensure high quality. Each user mobile station or equipment unit (UE) 30 is assigned its own scrambling code in order for a base station 28 to identify transmissions from that particular user equipment unit (UE) as well as for the user equipment unit (UE) to identify transmissions from the base station intended for that user equipment unit (UE) from all of the other transmissions and noise present in the same area.

Different types of control channels may exist between one of the base stations 28 and user equipment units (UEs) 30. For example, in the forward or downlink direction, there are several types of broadcast channels including a general broadcast channel (BCH), a paging channel (PCH), a common pilot channel (CPICH), and a forward access channel (FACH) for providing various other types of control messages to user

equipment units (UEs). In the reverse or uplink direction, a random access channel (RACH) is employed by user equipment units (UEs) whenever access is desired to perform location registration, call origination, page response, and other types of access operations. The random access channel (RACH) is also used for carrying certain user data, e.g., best effort packet data for, e.g., web browser applications. Traffic channels (TCH) may be allocated to carry substantive call communications with a user equipment unit (UE).

The present invention, which can be implemented in the example context of the telecommunications system of Fig. 3, particularly concerns a new and improved technique for establishing a link or leg of a radio connection in the radio access network. The inventive technique is advantageous in the event that a SRNC relocation procedure is performed for the user equipment unit (UE) which has been participating in that link or leg of the radio connection.

Particularly, in the present invention an end-to-end signaling protocol is utilized to establish, in a radio access network of a telecommunications system, plural distinct connection segments comprising a radio link or leg of a radio connection involving a user equipment unit. An example of an end-to-end signaling protocol is Q.AAL2.

As used herein, an end-to-end protocol is a protocol which confirms connection setup to an originating node only after a full path to a terminating node is through-connected, so that the user plane is set up and user data can be exchanged between end devices at the originating node and terminating node. Setting up a connection with such an end-to-end protocol typically begins with a message such as an "establish request" message which includes chosen parameters (e.g., CID, VP/VC value, and other traffic parameters in AAL2). The establish request message is sent from an originating node to a terminating node. The terminating node returns an "establish confirm" or similar signaling message. The user plane is then set up between the terminating node and the originating node so that user data can be exchanged between devices at those nodes.

In the present invention, the plural distinct connection segments extend in series between a device in a first radio network control node and a device in a base station controlled by a second radio network control node. The first radio network control

node serves as a serving radio network control (SRNC) node and the second radio network control serves as a drift radio network control (DRNC) node for the radio connection with the user equipment unit. Moreover, in the present invention the confirm establish messages provided by the end-to-end protocol for various distinct connection segments are sequenced so that the originating node does not receive an establish connection confirmation message in the connection layer until the user plane path is fully set up.

Provision of the plural distinct connection segments is advantageous when performing a SRNC relocation procedure to make the second radio network control node serve as the SRNC for the radio connection involving the user equipment unit. For example, after performance of the SRNC relocation procedure, a retained one of the plural distinct connection segments can still be utilized, e.g., a segment extending between the device in the base station controlled by the second radio network control node and a device at the second radio network control node. The retained one of the connection segments can either be utilized in series with a post-relocation connection segment to establish a path between the device in the base station controlled by the second radio network control node and a diversity handover unit at the second radio network control node, or have its endpoint moved to the diversity handover unit at the second radio network control node.

Two example modes of implementing the radio connection establishment technique of the present invention are illustrated. A first mode, known also as the three connection segment mode, is illustrated in Fig. 4A. Subsequent events involved with a SRNC relocation procedure facilitated by the first mode are illustrated in Fig. 4B and Fig. 4C. A second mode, known also as the two connection segment mode, is illustrated in Fig. 5A. Subsequent events involved with a SRNC relocation procedure facilitated by the second mode are illustrated in Fig. 5B, Fig. 5C, and Fig. 5D. Other modes of the invention, including modes having greater than three connection segments are within the scope of the present invention.

Both the first mode and the second mode are hereinafter described with reference to a user equipment unit (UE) 30 for which a radio link or leg of a radio connection is to be controlled initially by serving radio network controller (RNC) 26₁ and set up or established via base station 28₂₋₁. The base station 28₂₋₁ is controlled by

radio network controller (RNC) 26₂, which initially (e.g., before SRNC relocation) functions as a drift radio network controller (DRNC).

In the three connection segment mode illustrated generally in Fig. 4A, three distinct connection segments 400₁, 400₂, and 400₃ are established between serving radio network controller (RNC) 26₁ and a device in base station 28₂₋₁. A first of the connection segments, labeled as segment 400₁ in Fig. 4A, is established between a first device 25₂₋₁ at the second radio network control node (drift radio network controller (DRNC) 26₂) and a device in base station 28₂₋₁. Another (second) of the plural distinct connection segments, labeled as segment 400₂ in Fig. 4A, is established between the first device 25₂₋₁ at the second radio network control node and a second device 25₂ at the second radio network control node. Yet another (third) of the plural distinct connection segments, labeled as segment 400₃ in Fig. 4A, is established between the second device 25₂ at the second radio network control node and a device 27₁ at the first radio network control node (serving radio network controller (RNC) 26₁).

In the three connection segment mode (as well as in the two connection segment mode hereinafter described), each one of the plural distinct connection segments are segments of a radio link. All but a node internal radio link segment (e.g., all but the second radio link segment in the three connection segment mode) are established using an end-to-end protocol, such as AAL2 signaling, for example. In other words, the end-to-end protocol (e.g., AAL2 signaling) is used to establish node-transcending radio link segments, e.g., radio link segments which do not have both connection points in a same node.

As explained hereinafter, in the present invention the confirm establish messages provided by the end-to-end protocol for various distinct connection segments are sequenced so that the originating node (the first radio network control node, i.e., serving radio network controller (RNC) 26₁) does not receive an establish connection confirmation message in the connection layer (via the end-to-end signaling) until the user plane path is fully set up so that user data can be sent between the originating node and the terminating node (e.g., the device in base station 28₂₋₁).

To be specific, in the illustration of Fig. 4A the third segment 400₂ between ET device 25₂ in drift radio network controller (DRNC) 26₂ and device 27₁ in serving radio

network controller (RNC) 26₁ is established or set up with AAL2 signaling; the second segment 400₂ between ET device 25₂₋₁ and ET device 25₂ is established or set up using switching in drift radio network controller (DRNC) 26₂; and the first segment 400₁ between a device in base station 28₂₋₁ and ET device 25₂₋₁ is established or set up with AAL2 signaling. But the originating node (serving radio network controller (SRNC) 26₁) does not receive an establish confirmation signaling message until the entire user plane path has been setup between the originating node and the terminating node (e.g., the device in base station 28₂₋₁). This means that any other establish confirmation signaling sent with respect to any other connection segment (e.g., connection segment 400₁) must be properly coordinated or sequenced. In particular, establish confirmation signaling must be sent beginning in closest order of proximity of the corresponding connection segment to the terminating node.

The present invention thus differs from prior practice in various ways. For example, in prior practice usage of an end-to-end signaling protocol would mean set up or establishment of a radio link between end points of the device 27₁ and a device in base station 28₂₋₁.

In the illustrated embodiment, the first device 25₂₋₁ and the second device 25₂ at the second radio network control node 26₂ respectively can be or include a first connection point and a second connection point (e.g., at/in a first extension terminal [ET] and a second extension terminal [ET], respectively). In such implementation, the ET device 25₂ serves to interface drift radio network controller (DRNC) 26₂ over inter-RNC link 29 to serving radio network controller (RNC) 26₁. ET device 25₂₋₁ and ET device 25₂₋₂ serve to interface or connect drift radio network controller (DRNC) 26₂ to base station 28₂₋₁ and base station 28₂₋₂, respectively.

Thus, in the illustrated embodiment, connection points are situated at the first device 25₂₋₁ and the second device 25₂ at the second radio network control node 26₂. The term "connection point" is utilized since at these devices the end-to-end signaling protocol sets up a connection segment endpoint for each connection segment. In the illustrated embodiment wherein Q.AAL2 is employed to setup AAL2 channels, AAL2 channels are multiplexed onto ATM virtual channels (VCs) [multiplexing being utilized for different layers]. Therefore, while "connection point" is the more generic descriptor

for such points, in the more specific illustrated case of AAL2 such points are also herein referred to as "multiplexing points".

As mentioned above, in the illustrated embodiment extension terminals (ETs) serve as specific examples of first device 25_{2,1} and the second device 25₂. Various aspects of extension terminals (sometimes referred to as "exchange terminals") are generally described, e.g., in one or more of the following (all of which are incorporated herein by reference: United States Patent 6,128,295; U.S. Patent Application Serial Number 09/249,785, entitled "ESTABLISHING INTERNAL CONTROL PATHS IN ATM NODE", filed February 16, 1999; United States Patent 6,128,295; United States Patent 6,088,359; United States Patent 5,963,553; United States Patent 6,154,459; and United States Patent 6,034,958.

The drift radio network controller (DRNC) 26₂ comprises a diversity handover unit (DHO) 27₂ shown in Fig. 3, as well as other units and boards not illustrated. Among the other units of drift radio network controller (DRNC) 26₂ not illustrated in Fig. 3 can be a switch (e.g., a cell or packet switch) for interconnecting the constituent elements of drift radio network controller (DRNC) 26₂. Although such a switch is not shown in Fig. 3, an example radio network controller having such a switch is shown in Fig. 10.

In the illustrated embodiment, the device 27₁ is a diversity handover unit (DHO). The device 27₁ is in serving radio network controller (RNC) 26₁, which is involved in the third connection segment 400₃ of Fig. 4A. The serving radio network controller (RNC) 26₁ also has extension terminals in like manner as drift radio network controller (DRNC) 26₂ already-described, including extension terminal ET 25₁ which serves to interface serving radio network controller (RNC) 26₁ over inter-RNC link 29 to drift radio network controller (DRNC) 26₂. Although not shown in Fig. 4A, the person skilled in the art will appreciate that extension terminals (ETs) can also be employed for connection to each of the base stations controlled by serving radio network controller (RNC) 26₁. Furthermore, the serving radio network controller (RNC) 26₁ can also have a switch for interconnecting its constituent elements.

As mentioned above, the modes of the present invention are particularly advantageous for facilitating subsequent performance of a SRNC relocation or

moveover procedure. It will be recalled from the previous discussion that an SRNC relocation procedure occurs when it is determined that the role of a serving radio network controller (SRNC) for a radio connection involving a user equipment unit (UE) should be moved from one radio network controller to a node which, prior to the SRNC relocation, had been serving as a drift radio network controller (DRNC).

Fig. 4B and Fig. 4C illustrate certain basic actions pertaining to a SRNC relocation performed after a radio link has been set up in accordance with the three connection segment mode of Fig. 4A. Advantageously the first connection segment 400₁ can be retained after completion of the SRNC relocation to comprise the radio connection with user equipment unit (UE) 30. The first connection segment 400₁ is the connection segment between base station 28₂₋₁ and ET device 25₂₋₁. Fig. 4B shows that, upon implementing SRNC relocation, the first connection segment 400₁ can still be utilized, along with two new additional connection segments, e.g., connection segment 400₄ and connection segment 400₅. The new connection segment 400₄ is established or set up between ET device 25₂₋₁ of serving radio network controller (RNC) 26₁ and the diversity handover unit (DHO) 27₂ of drift radio network controller (DRNC) 26₂. The new connection segment 400₅ is established or set up between the diversity handover unit (DHO) 27₂ of drift radio network controller (DRNC) 26₂ and the core network 16. Both the new connection segment 400₄ and new connection segment 400₅, like connection segment 400₁ before them, are preferably set up using an end-to-end signaling protocol such as AAL2.

Fig. 4B also shows by broken lines that the former second connection segment 400₂ and former third connection segment 400₃ are no longer needed after the SRNC relocation. Fig. 4C shows that, after SRNC relocation, the former second connection segment 400₂ and former third connection segment 400₃ have been broken down, leaving only the retained connection segment 400₁, new connection segment 400₄, and new connection segment 400₅.

Thus, subsequent to performance of the SRNC relocation procedure, the first connection segment 400₁ is utilized in series with two post-relocation connection segments, e.g., new connection segment 400₄ and new connection segment 400₅, to establish a path (e.g., radio link or leg) between a device in the base station controlled

by the second radio network control node (e.g., base station 28₂₋₁) and the core network 16.

In the two connection segment mode illustrated generally in Fig. 5A, two distinct connection segments 500₁ and 500₂ are established between serving radio network controller (RNC) 26₁ and base station 28₂₋₁. A first of the connection segments, labeled as segment 500₁ in Fig. 5A, is established between a device (e.g., device 25₂) at the second radio network control node (drift radio network controller (DRNC) 26₂) and a device in base station 28₂₋₁. Another (second) of the plural distinct connection segments, labeled as segment 500₂ in Fig. 5A, is established between the device (e.g., device 25₂) at the second radio network control node and a device (e.g., device 27₁) at the first radio network control node. Thus, in contrast to the three connection segment mode, in the two connection segment mode the first segment, e.g., the segment 500₁ having a first end point connected to base station 28₂₋₁ has its second endpoint connected to ET device 25₂ rather than to ET device 25₂₋₁.

In the two connection segment mode, each one of the plural distinct connection segments are segments of a radio link. As in the three connection segment mode, each such radio link segment is established using an end-to-end protocol, such as AAL2 signaling, for example. To be specific, the second segment 500₂ between ET device 25₂ and DHO 27₁ is established or set up with AAL2 signaling; and the first segment 500₁ between the device in base station 28₂₋₁ and ET device 25₂ is established or set up with AAL2 signaling. In like manner as the three connection segment mode, establish confirmation signaling must be sent beginning in closest order of proximity of the corresponding connection segment to the terminating node (e.g., base station 28₂₋₁), so that the originating node (e.g., serving radio network controller (SRNC) 26₁ at which DHO 27₁ is situated) receives establish confirmation signaling only after the entire user plane path has been setup. It is again mentioned that this differs from prior practice, since in prior practice usage of an end-to-end signaling protocol would mean set up or establishment of a radio link between end points of the device 27₁ and a device in base station 28₂₋₁.

In the two connection segment mode, a first connection segment 500₁ is referred to as a first or retainable one of the plural distinct connection segments. The device in drift radio network controller (DRNC) 26₂ which forms a second endpoint of the first

connection segment 500₁ is, in the illustrated example embodiment, a connection point (e.g., multiplexing point at an extension terminal [ET]) situated between an unillustrated switch of the second radio network control node 26₂ and the inter-RNC link 29 to the first radio network control node 26₁. Although the switch comprising the example, representative drift radio network controller (DRNC) 26₂ is unillustrated in Fig. 5A, its nature and operation will be understood from the example node shown in and subsequently described with reference to Fig. 10.

Fig. 5B, Fig. 5C, and Fig. 5D illustrate certain basic actions pertaining to a SRNC relocation performed after a radio link has been set up in accordance with the two connection segment mode of Fig. 5A. Fig. 5B shows that the SRNC relocation will involve a new connection segment 500₃ which extends between core network 16 and the DHO device 27₂ of drift radio network controller (DRNC) 26₂. The new connection segment 500₃, like connection segment 500₁ before it, is preferably set up using an end-to-end signaling protocol such as AAL2.

Further, as shown by arrow S in Fig. 5C, a second endpoint of connection segment 500₁ is moved from ET device 25₂ to the DHO device 27₂. The first connection segment 500₁ is the connection segment which has its first endpoint connected to base station 28₂₋₁. With its second endpoint thusly moved, the first connection segment 500₁ can be retained after completion of the SRNC relocation to comprise the radio connection with user equipment unit (UE) 30.

Fig. 5C also shows by broken lines that the former second connection segment 500₂ is no longer needed after the SRNC relocation. Fig. 5D shows that, after SRNC relocation, the former second connection segment 500₂ has been broken down, leaving only the retained connection segment 500₁ and new connection segment 500₃.

Thus, subsequent to performance of the SRNC relocation procedure, the first connection segment 500₁, with its second endpoint moved within drift radio network controller (DRNC) 26₂, is utilized in series with post-relocation connection segment 400₃, to establish a path (e.g., radio link or leg) between the base station controlled by the second radio network control node (e.g., base station 28₂₋₁) and the core network 16.

Fig. 10 illustrates, in somewhat more detail, an example non-limiting RNC node 26_G of the present invention. RNC node 26_G of Fig. 10 can represent an serving RNC (SRNC) or a drift RNC (DRNC). It so happens that the RNC node 26 of Fig. 10 is a switched-based node having a switch 120. The switch 120 serves to interconnect other constituent elements of RNC node 26_G. Such other constituent elements include extension terminals [ETs] 125_{G-1} through 125_{G-n}, extension terminal 125₁ which connects RNC node 26_G via the inter-RNC link 29 to another radio network controller; and extension terminal 124. Extension terminals 125_{G-1} through 125_{G-n} essentially function to connect RNC node 26_G to the base stations 28 served by RNC node 26_G; extension terminal 124 connects RNC node 26 across the Iu interface to the core network 16. Yet other constituent elements of RNC node 26_G include diversity handover unit 27_G; codex 130; timing unit 132; a data services application unit 134; and, a main processor 140.

Fig. 11 illustrates, in non-limiting manner, more details of an example base station (BS) node 28 in accordance with one embodiment of the present invention. As with RNC node 26, the base station (BS) node 28 of Fig. 11 is a switched-based node having a switch 220 which serves to interconnect other constituent elements of base station (BS) node 28. Such other constituent elements include extension terminal (ET) 222; BS main processor 240, and interface (IF) boards 242. It is an interface board 242 which, in the scenario of Fig. 4A and Fig. 5A, is the device in the base station 28₂₋₁ which serves as the first endpoint of the first connection segment. This interface board 242 is sometimes referred to as the RX/TX device.

Extension terminal (ET) 222 connects base station (BS) node 28 to radio network controller (RNC) node 26, and thus comprises the Iub interface. Preferably included in the extension terminal 222 is a function which provides, e.g., multiplexing and demultiplexing and (optionally) queuing with regard to differing protocols of cells. Alternatively, a separate unit which performs these functions can be situated in BS 28₂₋₁ external to extension terminal ET.

The embodiment of base station (BS) node 28 illustrated in Fig. 11 is housed in a rack having multiple subracks. Each subrack has one or more boards, e.g., circuit boards, mounted thereon. A first subrack 250 contains boards for each of extension terminal 222; BS main processor 240, and interface boards 242. Each of the interface

boards 242 is connected to a board on another subrack, e.g., one of the transmitter boards 260 or one of the receiver boards 270. Each receiver board 270 is connected to share certain transmitter/receiver resources in a corresponding transmitter board 260, with the transmitter board 260 being connected to a corresponding one of amplifiers and filters board 280. The amplifiers and filters board 280 is connected to an appropriate antenna 39. For example, interface board 242_{1-T} is connected to transmitter board 260₁, while interface board 242_{1-R} is connected to receiver board 270₁. The pair of transmitter board 260₁ and receiver board 270₁ is, in turn, connected to amplifiers and filters board 280₁. Similar connections exist for a second pairing of transmitter board 260₂ and receiver board 270₂, which interface via interface board 242_{2-T} and interface board 242_{2-R}, respectively. Each transceiver 38 of Fig. 2 thus comprises a subrack which includes a transmitter board 260, a receiver board 270, and amplifiers and filters board 280.

In one example, non-limiting embodiment, base station (BS) node 28 is an ATM-based node, with interface boards 242 performing various ATM interfacing functions. The transmitter boards 260 and receiver boards 270 each include several devices. For example, each transmitter board 260 includes unillustrated elements such as an interface connected to its corresponding interface board 242; an encoder; a modulator; and, a baseband transmitter. In addition, the transmitter board 260 includes the transmitter/receiver resources which it shares with receiver board 270. Each receiver board 270 includes unillustrated elements such as an interface connected to its corresponding interface board 242; a decoder; a demodulator; and, a baseband receiver. Each amplifiers and filters board 280 includes amplifiers, such as MCPA and LNA amplifiers.

The distinct plural radio connection or link segments of the present invention can be established using binding information to bind together a call layer and a connection layer. In this regard, telecommunications networks are typically conceptualized as having layered functionalities. The physical layer comprises a network of switches and cables (e.g., trunk lines) which are employed to connect devices (e.g., telephones, either mobile or stationary) involved in a call (e.g., a "connection"). The connection layer is an abstraction that comprises a model of the physical network. Connection handling (which is performed over the connection layer) relates to the set up and release of connections and to the control of the physical telecommunications network. The call

layer is involved in service handling, which includes service control, service execution, service signaling, service installation, service modification, and service administration. Within each layer information is transferred over signaling entities within the layer.

In some telecommunication systems, the call layer information and the connection layer information is signaled and routed along the same path from a call origin to a call destination. In such case, the resources needed for the call establishment are reserved hop by hop (e.g., as the information is signaled and routed from switch to switch through the physical network). As the call layer and connection layer are therefore closely coupled to each other, the binding between the call layer and the connection layer is resolved in runtime.

Modern telecommunication networks usually have the call layer and the connection layer separated from one another. As a consequence of the separation of the call layer and the connection layer, different networks are used for the call establishment and the connection establishment. The two networks (the call layer network and the connection layer network) usually have different topologies.

In operation, in setting up a call usually a call layer connection is initially established over the call layer network between two devices. Typically establishing the call layer connection involves exchange of control information that does not need any user plane (e.g., physical layer) connection. Subsequently, when a user plane connection is needed over the physical layer, a connection is established in the connection layer.

The two connections -- the call layer connection and the connection layer connection -- are routed from the same origin to the same destination. However, in view of the differing topologies of the call layer network and the connection layer network, the two connections do not have to be routed along the same path. The advantage of separate routing of the call layer connection and the connection layer connection is that resources for the user plane connection are only reserved and used when needed. Examples of call and connection separated telecommunications networks are provided in the following, all of which are incorporated herein by reference in their entirety: Swedish Patent Application 9601605-0, filed April 26, 1996; United States Patent 5,809,129; and, United States Patent 5,710,882.

The separation of the call layer and the connection layer does, however, require some type of mechanism to bind the two layers to each other at certain nodes where the two layers meet. The signaling protocol of each layer needs to carry the binding mechanism, e.g., binding information. Typically, existing networks with existing protocols are used, and the binding information must be fit into already defined information entities within those protocols.

In the above regard, both in a core network and in a radio access network, the call layer generally uses a signaling system No. 7 (SS7) network or a TCP/IP network for call control signaling. On top of the SS7 or the TCP/IP protocol stacks there is an application protocol, such as RNSAP or RANAP. The RNSAP and RANAP protocols are used end-to-end in the network. Application specific resources, such as diversity handover units (DHOs) and codecs (coders/decoders) are handled and reserved at the call layer.

In one of its aspects, the present invention provides various binding information techniques for the multiple connection segment modes when the call and the connection layers are separated in a telecommunications network. An example binding technique for the three connection segment mode (of Fig. 4A - Fig. 4C) is illustrated in Fig. 6. Fig. 6 shows, from a layering perspective, the three nodes of the serving radio network controller (SRNC) 26₁, the drift radio network controller (DRNC) 26₂, and the base station 28₂₋₁. In Fig. 6, a physical layer is illustrated as being below dashed double-dotted line 630. The physical layer comprises a network of switches and cables or links (e.g., trunk lines) which are employed to connect devices such as diversity handover unit (DHO) 27₁ and device 624₃. In the illustrated embodiment, each of the three nodes has a switch, e.g., switch 120₁ for serving radio network controller (SRNC) 26₁; switch 120₂ for drift radio network controller (DRNC) 26₂; and switch 120₃ for base station 28₂₋₁. To a switch port of switch 120₁ which are outgoing from end node 26₁ is connected extension terminal 25₁, only one such extension terminal 25₁ being shown in Fig. 6 for sake of simplification. Likewise, respective switch ports of switch 120₂ of drift radio network controller (DRNC) 26₂ are connected to extension terminals 25₂ and 25₂₋₁, which have been discussed above. A switch port of switch 27₃ of base station 28₂₋₁ is connected to extension terminal 25₃. As is understood to those skilled in the art, it is through extension terminals such as extension terminals 25 in Fig. 6 that a switch is connected in the physical layer to other nodes.

The information used to identify a connection endpoint, known herein as connection endpoint information, varies from switch to switch, and depends on conventions of the switch vendor/manufacturer. The connection endpoint information can thus be vendor specific for a physical layer entity, and may take the form of a concatenation of one or more of a node identifier, a hardware cabinet rack, a hardware slot, a hardware port, and a resource, for example.

The connection layer is shown in Fig. 6 above the physical layer, e.g., between dashed double-dotted line 630 and dash dotted line 640. In each node, the connection layer includes a connection layer control process. For example, a connection layer control process 42₁ is performed at serving radio network controller (SRNC) 26₁, a connection layer control process 42₂ is performed at drift radio network controller (DRNC) 26₂; and a connection layer control process 42₃ is performed at base station 28₂₋₁. The call layer is shown in Fig. 6 above the connection layer, e.g., above dash dotted line 640. In each node, the call layer includes a connection layer control process. Again by way of example, a call layer control process 52₁ is illustrated in Fig. 6 for serving radio network controller (SRNC) 26₁; a call layer control process 52₂ is illustrated for drift radio network controller (DRNC) 26₂; and a call layer control process 52₃ is illustrated for base station 28₂₋₁.

In general, whenever a user plane connection is needed to be set up in the physical layer, an order is given in the form of a connection request from the call layer to the connection layer. The connection endpoints of the application specific resources must be addressable at the connection layer. The connection is established using an appropriate connection layer signaling protocol, e.g., B-ISUP signaling for ATM connections or Q.AAL2 for AAL2 connections. The connection layer signaling is routed through the connection layer and controls reservation and through connection of connection layer resources (e.g., switches and extension terminals) along the path to the destination end node.

An example of using binding information for the three connection segment mode of the present invention is described with reference to certain example basic actions in Fig. 6. In Fig. 6 and similar figures, the term "connection point" encompasses endpoints of the connection segments described above. Moreover, when the connection

segment endpoint is also an endpoint of the overall connection, the further refined term "connection endpoint" may be employed for more specificity.

Concerning first the third segment 400₃ (see Fig. 4A), as action 6-1 the call layer (more specifically call layer control process 52₂ at drift radio network controller (DRNC) 26₂) obtains a binding reference to represent a connection point associated with the connection point (e.g., multiplexing point) furnished by extension terminal 25₂. Since the connection points are selected by the connection layer, when setting up the connection a table, such as table 70 maintained by connection layer process 70₂, cannot reserve a connection point in advance. Therefore, in accordance with one aspect of the present invention, the value of the binding reference obtained as action 6-1 can be in a predetermined range which is reserved for setting up network-wide AAL2 connections to a connection/multiplexing point (e.g., a predetermined range binding reference values which specifies that the connection is to be routed to an incoming connection/multiplexing point, and therefore is a connection point corresponding to an endpoint of a segment). The terminating node can then, by examining the binding reference, determine from the range to which the binding reference belongs that it is for setup of a connection segment. The binding reference can be obtained from the connection layer, or alternatively obtained from the call layer. Fig. 6 particularly shows as action 6-1 obtaining the binding reference. The binding reference can be obtained, but does not have to be obtained, from a table such as table 70₂. Table 70₂ associates the binding reference with the appropriate connection point, e.g., connection point 636₂ at extension terminal 25₂ in Fig. 6. The connection point is described by connection point information which, as mentioned above, can be vendor specific information.

As an example, the binding information can be standardized for Q.AAL2. In particular, such binding information is standardized in ITU-T Q.2630.1 to be a fixed size field of four octets. The binding information is named "Served User Generated Reference" (SUGR) in the Q.2630.1 specification. However, the ITU-T Q.2630.1 standard does not limit or imply anything regarding how those values are assigned to the SUGR.

Another possibility for obtaining the connection point is to have table 70₂ associate a binding reference (e.g., any appropriate SUGR value) and a predetermined value, e.g., a predetermined or null value employed specifically for this purpose, instead of a connection point value. Upon finding the predetermined (e.g., null) value

associated with a binding reference in table 70₂, the connection layer knows it is a segment setup and that the connection is only to be routed to the connection point. In this situation any SUGR value can be used and no SUGR range has to be reserved. Alternatively, these two techniques can be used in conjunction with one another -- both a predefined range and also the predetermined or null value can be employed as a precaution.

As action 6-2, the call layer control process 52₂ of drift radio network controller (DRNC) 26₂ transmits a call layer signaling message to serving radio network controller (SRNC) 26₁. The call layer signaling message of action 6-2 can include the binding information (BI) and an ATM end system address (AESA) of drift radio network controller (DRNC) 26₂ in Fig. 6. The call layer signaling message of action 6-2 can be in the form of an appropriate existing protocol, such as RANAP, RNSAP, and NBAP when the telecommunications network is a radio access network known as UTRAN. In any call and connection separated network the call layer must extend this information in order to make it possible for the connection layer to route the connection. As is understood generally and illustrated subsequently, the AESA of drift radio network controller (DRNC) 26₂ carried in the call layer signaling message is used for signal routing to drift radio network controller (DRNC) 26₂.

The concept of ATM end system address (AESA) is described, e.g., in section 73.0 of *ATM User-Network Interface (UNI) Signaling Specification*, Version 74.0, af-sig-0061.00, July 1996, generated by the ATM Forum Technical Committee, which specifies the use of standard ATM addresses for private and public networks. In general, and AESA has an initial domain part (IDP) and a domain specific part (DSP). The initial domain part (IDP) comprises two fields: the authority and format identifier (AFI) and the initial domain identifier (IDI). The domain specific part (DSP) is subdivided into a high order DSP (HO-DSP) and a low order part which consists of the end system identifier (ESI) and a selector (SEL).

Upon receipt of the call layer signaling message of action 6-2, as action 6-3 the call layer control process 52₁ of serving radio network controller (SRNC) 26₁ reserves a connection endpoint at serving radio network controller (SRNC) 26₁. As illustrated in Fig. 6, the particular connection endpoint reserved by action 6-3 is connection endpoint 636₁ on/at DHO device 27₁. Thereafter, as action 6-4, the call layer control process 52₁

sends a connection request signaling message to the connection layer. The connection request signaling message sent to the connection layer as action 6-4 includes the AESA of drift radio network controller (DRNC) 26₂, the binding information, and the connection endpoint reserved at action 6-3 (e.g., connection endpoint 636₁).

As a result of receipt of the connection request of action 6-4, as action 6-5 the connection layer control process 42₁ handles the extension terminal 25₁ and through connects switch 120₁ so that endpoint 636₁ is connected to extension terminal 25₁. Action 6-6 involves the routing of connection layer signaling through the connection layer from serving radio network controller (SRNC) 26₁ to drift radio network controller (DRNC) 26₂. The connection layer signaling can be, for example, an "establish request" message and includes the binding information and the AESA of drift radio network controller (DRNC) 26₂. The connection layer signaling message of action 6-6 can be in any of several protocols, including Q.AAL2, B-ISUP, and PNNI. B-ISUP and PNNI are examples of protocols used to set up ATM connections, although not used in 3GPP (since AAL2 is standardized).

Upon receipt of the connection layer signaling (establish request message) of action 6-6, the connection layer control process 42₂ in the connection layer at drift radio network controller (DRNC) 26₂ accesses the binding information included therein. Using the binding information obtained from the connection layer signaling, as action 6-7 the connection layer control process 42₂ accesses table 70₂ to obtain the appropriate connection point information, i.e., the connection endpoint information for connection point 636₂. The call layer control process 52₂ at drift radio network controller (DRNC) 26₂ then gets an indication (represented by event 6-8) that the connection segment has been routed to a connection/multiplexing point (e.g., extension terminal 25₂) in drift radio network controller (DRNC) 26₂.

Having described above usage of binding information for setting up the third connection segment 400₃ of the three connection segment mode, attention now turns to setting up of the first connection segment 400₁ between extension terminal 25₂₋₁ at drift radio network controller (DRNC) 26₂ and the base station 28₂₋₁ (particularly device 624₃ at base station 28₂₋₁). As hereinafter exemplified, the device 624₃ at base station 28₂₋₁ can be an interface which has a transmit/receive (TX/RX) function, for example.

Concerning the first connection leg 400₁ of the three connection segment mode, as action 6-10 at base station 28₂₋₁ the call layer (more specifically call layer control process 52₃) reserves a connection endpoint (e.g., connection endpoint 636₃). The connection endpoint is described by connection endpoint information which, as mentioned above, can be vendor specific information (e.g., a concatenation of node, cabinet rack, slot, port, and resource). As action 6-11, the call layer (more specifically call layer control process 52₃ at base station 28₂₋₁) obtains a binding reference to represent a connection endpoint 636₃. As with action 6-1 previously discussed, the binding reference of action 6-11 can be obtained from the connection layer, or alternatively obtained from the call layer. Fig. 6 particularly shows as action 6-11 obtaining the binding reference from a table 70₃ maintained by the connection layer control process 42₃.

As action 6-12, the call layer control process 52₂ of base station 28₂₋₁ transmits a call layer signaling message to drift radio network controller (DRNC) 26₂. The call layer signaling message of action 6-12 can include the binding information (BI) obtained as action 6-11 and an ATM end system address (AESAs) of base station 28₂₋₁. As with the comparable message of action 6-2, the call layer signaling message of action 6-12 can be in the form of an appropriate existing protocol, such as RANAP, RNSAP, and NBAP when the telecommunications network is a radio access network known as UTRAN.

Upon receipt of the call layer signaling message of action 6-12, as action 6-13 the call layer control process 52₂ of drift radio network controller (DRNC) 26₂ reserves a second connection point for connection segment 400₁. As illustrated in Fig. 6, the particular connection point reserved by action 6-13 is connection point 636₂₋₁ representing a connection/multiplexing point provided by extension terminal 25₂₋₁. Thereafter, as action 6-14, the call layer control process 52₂ sends a connection request signaling message to the connection layer. The connection request signaling message sent to the connection layer as action 6-14 includes the AESA of base station 28₂₋₁, the binding information, and the connection point reserved at action 6-13 (e.g., connection point 636₂₋₁).

Action 6-15 involves the routing of connection layer signaling (e.g., an establish request message) through the connection layer from drift radio network controller (DRNC) 26₂ to base station 28₂₋₁. The connection layer signaling of action 6-15

includes the binding information and the AESA of base station $28_{2.1}$. In like manner as stated previously, the connection layer signaling message of action 6-15 can be in any of several protocols, including Q.AAL2, B-ISUP, and PNNI.

Upon receipt of the connection layer signaling of action 6-15, the connection layer control process 42_3 in the connection layer base station $28_{2.1}$ accesses the binding information included therein. Using the binding information obtained from the connection layer signaling, as action 6-16 the connection layer control process 42_3 accesses table 70_3 to obtain the appropriate connection endpoint information, i.e., the connection endpoint information for connection endpoint 636_3 . Then, as action 6-17 the call layer control process 52_3 at base station $28_{2.1}$, using the vendor-specific connection endpoint information acquired from table 70_3 , issues signals to through connect switch 120_3 , so that the connection endpoint 636_3 associated with the connection endpoint information is through connected to device 624_3 .

Action 6-18 of Fig. 6 shows that, upon through connection of switch 120_3 as above described relative to action 6-17, the connection layer control process 42_3 at the terminating node (e.g., base station $28_{2.1}$) sends an establish confirm signaling message to drift radio network controller (DRNC) 26_2 . As explained herein, it is imperative that the establish confirm message of action 6-18 be sent before any establish confirm message is provided to the originating node, e.g., to serving radio network controller (SRNC) 26_1 . Upon receipt of the establish confirm message of action 6-18, as action 6-19 the connection layer control process 42_2 at drift radio network controller (DRNC) 26_2 sends a confirm notification indication to call layer control process 52_2 at drift radio network controller (DRNC) 26_2 .

Concerning the second connection segment 400_2 (see Fig. 4A), the call layer control process 52_2 at drift radio network controller (DRNC) 26_2 connects connection point 636_2 (on extension terminal 25_2) and connection point $636_{2.1}$ (on extension terminal $25_{2.1}$) with a node-internal connection through switch 120_2 . In this regard, Fig. 6 shows as action 6-20 the call layer control process 52_2 at drift radio network controller (DRNC) 26_2 issuing a connection request to connection layer control process 42_2 to implement the node-internal connection, and action 6-21 in turn shows connection layer control process 42_2 issuing command(s) to the physical layer to through connect switch 120_2 for connecting connection point 636_2 and connection point $636_{2.1}$.

After switch 120₂ is through connected in the manner described by action 6-21, and since the establish confirm message of action 6-18 has been received from base station 28₂₋₁, as action 6-22 call layer control process 52₂ of drift radio network controller (DRNC) 26₂ requests over application programmable interface API₂ that connection layer control process 42₂ send an establish confirm message from drift radio network controller (DRNC) 26₂ to serving radio network controller (RNC) 26₁. Fig. 6 shows that, as action 6-23, the connection layer control process 42₂ sends an establish confirm message to the originating node (e.g., serving radio network controller (SRNC) 26₁). Thus, the establish confirmation signaling is properly coordinated or sequenced, so that the establish confirmation signaling is sent beginning in closest order of proximity of the corresponding connection segment to the terminating node. In this regard, the establish confirm message of action 6-18 (for connection segment 400₁) was sent prior to sending of the establish confirm message of action 6-23 (for connection segment 400₃) .

As evident from the above description, the call layer handles three connection segments instead of one end-to-end connection. In the illustrated embodiment this is accomplished using three different application programmable interfaces (APIs), specifically application programmable interface API₁, application programmable interface API₂, and application programmable interface API₃. As shown in Fig. 6, the application programmable interface API₁ exists in the serving radio network controller (RNC) 26₁; the application programmable interface API₂ exists in the drift radio network controller (DRNC) 26₂; and the application programmable interface API₃ exists in the base station 28₂₋₁. These application programmable interfaces are utilized in the manners described above. For example, the application programmable interface API₂ which is introduced into drift radio network controller (DRNC) 26₂ informs the call layer (e.g., call layer control process 52₂) that the connection is routed to a connection point on an ET at drift radio network controller (DRNC) 26₂. The call layer obtains the VP/VC and CID on the incoming ET which is used to setup the second segment. The call layer may also have to inform the connection layer (E.g., connection layer control process 42₂) over the application programmable interface API₂ to send an establish confirm message (e.g., the message of action 6-23) from drift radio network controller (DRNC) 26₂ to serving radio network controller (RNC) 26₁ when an establish confirm message (e.g., the message of action 6-18) has been received over from base

station 28₂₋₁, thereby reflecting the fact that a full path from device to device has been through connected.

An example of using binding information for the two connection segment mode of the present invention (illustrated in Fig. 5A - Fig. 5D) is described with reference to certain example basic actions in Fig. 7. In the second connection segment mode the call layer uses the already-reserved connection point 636₂ on the incoming extension terminal 25₂ as the origination point for the first connection segment 500₁. The call layer in the second connection segment mode orders that a connection segment be set up from the incoming extension terminal 25₂ to the destination point 636₃. The connection layer thus routes the first connection segment 500₁ over an outgoing extension terminal 25₂₋₁ to the base station 28₂₋₁ (and reserves a connection/multiplexing point on the extension terminal 25₂₋₁), and through connects switch 120₂ of drift radio network controller (DRNC) 26₂ so that the base station 28₂₋₁ can be signaled using Q.AAL2. Thus, instead of handling three segments or fragments, in the second connection segment mode only two segments are utilized. Moveable connection points must be supported by the connection layer in this second connection segment mode.

For the two connection segment mode, the connection segment 500₂ (see Fig. 5A) is set up using binding information in the same manner as the third connection segment 400₃ of the three connection segment mode. For this reason, actions 7-1 through 7-8 of Fig. 7 are essentially identical to actions 6-1 through 6-8 of Fig. 6. Set up of the first connection leg 500₁ of the second connection segment mode, however, differs from procedures described in the three connection segment mode, as discussed below.

Concerning in more detail the first connection leg 500₁ of the second connection segment mode, as action 7-10 at base station 28₂₋₁ the call layer (more specifically call layer control process 52₃) reserves a connection endpoint (e.g., connection endpoint 636₃). The connection endpoint is described by connection endpoint information which, as mentioned above, can be vendor specific information (e.g., a concatenation of node, cabinet rack, slot, port, and resource). As action 7-11, the call layer (more specifically call layer control process 52₃ at base station 28₂₋₁) obtains a binding reference to represent a connection endpoint 636₃. As previously discussed, the binding reference of action 7-11 can be obtained from the connection layer, or alternatively

obtained from the call layer. Fig. 7 particularly shows as action 7-11 obtaining the binding reference from a table 70₃ maintained by the connection layer control process 42₃.

As action 7-12, the call layer control process 52₂ of base station 28₂₋₁ transmits a call layer signaling message to drift radio network controller (DRNC) 26₂. The call layer signaling message of action 7-12 can include the binding information (BI) obtained as action 7-11 and an ATM end system address (AESAs) of base station 28₂₋₁. The call layer signaling message of action 7-12 can be in the form of an appropriate existing protocol, such as RANAP, RNSAP, and NBAP when the telecommunications network is a radio access network known as UTRAN.

The call layer control process 52₂ of drift radio network controller (DRNC) 26₂ need not reserve a connection point for connection segment 500₁, since already-reserved connection point 636₂ will be utilized for one endpoint of connection segment 500₁. The call layer control process 52₂ can then proceed to action 7-14, which is the sending of a connection request signaling message to the connection layer control process 42₂. The connection request signaling message sent to the connection layer as action 7-14 includes the AESA of base station 28₂₋₁, the binding information, and the already-reserved connection point (e.g., connection point 636₂).

As action 7-15A, the connection layer control process 42₂ reserves an outgoing multiplexing connection on extension terminal 25₂₋₁ and through connects switch 120₂ (so that the outgoing multiplexing connection on extension terminal 25₂₋₁ is connected to connection point 636₂ on extension terminal 25₂). Subsequently, as action 7-15B, the connection layer control process 42₂ sends connection layer signaling through the connection layer from drift radio network controller (DRNC) 26₂ to base station 28₂₋₁. The connection layer signaling of action 7-15B includes the binding information and the AESA of base station 28₂₋₁. In like manner as above mentioned, the connection layer signaling message of action 7-15B can be in any of several protocols, including Q.AAL2, B-ISUP, and PNNI.

Upon receipt of the connection layer signaling of action 7-15B, the connection layer control process 42₃ in the connection layer base station 28₂₋₁ accesses the binding information included therein. Using the binding information obtained from the connection layer signaling, as action 7-16 the connection layer control process 42₃

accesses table 70₃ to obtain the appropriate connection endpoint information, i.e., the connection endpoint information for connection endpoint 636₃. Then, as action 7-17 the call layer control process 52₃ at base station 28₂₋₁, using the vendor-specific connection endpoint information acquired from table 70₃, issues signals to through connect switch 120₃, so that the connection endpoint 636₃ associated with the connection endpoint information is through connected to device 624₃, thereby setting up the first connection segment 500₁ for the second connection segment mode.

Action 7-18 of Fig. 7 shows that, upon through connection of switch 120₃ as above described relative to action 7-17, the connection layer control process 42₃ at the terminating node (e.g., base station 28₂₋₁) sends an establish confirm signaling message to drift radio network controller (DRNC) 26₂. Upon receipt of the establish confirm message of action 7-18, as action 7-19 the connection layer control process 42₂ at drift radio network controller (DRNC) 26₂ sends a confirm notification indication to call layer control process 52₂ at drift radio network controller (DRNC) 26₂. Then, as action 7-22, call layer control process 52₂ of drift radio network controller (DRNC) 26₂ requests over application programmable interface API₂ that connection layer control process 42₂ send an establish confirm message from drift radio network controller (DRNC) 26₂ to serving radio network controller (RNC) 26₁. Fig. 6 shows that, as action 7-23, the connection layer control process 42₂ sends an establish confirm message to the originating node (e.g., serving radio network controller (SRNC) 26₁).

The indication 7-19 from connection layer control process 42₂ to call layer control process 52₂, and the direction of action 7-22 from call layer control process 52₂ to connection layer control process 42₂ exist in view of the fact that connection segments 500₁ and 500₂ are treated as separate connections which need to know of each other and the call layer must coordinate that the different connection segments belong to the same call.

Thus, as in the three connection segment mode, in the two connection segment mode the establish confirmation signaling is again properly coordinated or sequenced, so that the establish confirmation signaling is sent beginning in closest order of proximity of the corresponding connection segment to the terminating node. In this regard, the establish confirm message of action 7-18 (for connection segment 500₁) was sent prior to sending of the establish confirm message of action 7-23 (for connection segment 500₂).

The illustrated embodiments representatively depict a single connection layer process in the connection layer for each node. It should be understood, however, that it may be preferable to have in each node a separate connection layer process for each connection segment.

Fig. 8 is a diagrammatic view showing basic example actions involved a call layer and connection layer binding technique for the three connection segment mode of the invention during an SRNC relocation procedure. Fig. 8 thus shows the nodes involved in the three connection segment mode at a time subsequent to Fig. 6. As action 8-1, the call layer control process 52₂ reserves a connection point 636_{DHO} in diversity handling (DHO) unit 27₂. Then, as action 8-2, the call layer control process 52₂ sends a connection request message to connection layer control process 42₂. The connection request message of action 8-2 requests that the connection/multiplexing point represented by connection point 636₂₋₁ on outgoing extension terminal 25₂₋₁ be connected through switch 120₂ with the connection point 636_{DHO} of diversity handling (DHO) unit 27₂. Action 8-3 shows the connection layer control process 42₂ of drift radio network controller (DRNC) 26₂ issuing the command(s) to the physical layer to through connect switch 120₂ to accommodate the connection request message of action 8-2, thereby forming the connection segment 400₄ (see Fig. 4B).

For sake of simplicity, Fig. 8 does not show the tearing down of the connection segments 400₂ and 400₃. Removal of the connection segments 400₂ and 400₃ is part of the SRNC relocation procedure, and understood by the person skilled in the art, e.g., in view of the foregoing.

Fig. 9 is a diagrammatic view showing basic example actions involved a call layer and connection layer binding technique for the two connection segment mode of the invention (see Fig. 5A - Fig. 5D) during an SRNC relocation procedure. Fig. 9 thus shows the nodes involved in the two connection segment mode at a time subsequent to Fig. 7. As action 9-1, the call layer control process 52₂ reserves a connection point 636_{DHO} in diversity handling (DHO) unit 27₂. Then, as action 9-2, the call layer control process 52₂ sends a move point request message to connection layer control process 42₂. The move point request message of action 9-2 requests that second endpoint of connection segment 500₁ be moved from the connection/multiplexing point represented by connection point 636₂ on incoming extension terminal 25₂ to the connection point 636_{DHO} of diversity handling (DHO) unit 27₂. Action 9-3 shows the connection layer

control process 42₂ of drift radio network controller (DRNC) 26₂ issuing the command(s) to the physical layer to through connect switch 120₂ to accommodate the connection request message of action 9-2, thereby moving the second endpoint of the connection segment 500₁ in the manner depicted by arrow S (see Fig. 5C and Fig. 9).

5 Again for sake of simplicity, Fig. 9 does not show the tearing down of the connection segment 500₂. Removal of the connection segment 500₂ is part of the SRNC relocation procedure, and understood by the person skilled in the art, e.g., in view of the foregoing.

10 Thus, the present invention utilizes binding information to accommodate employment of the multiple connection segments such as described in the three connection segment mode of Fig. 4A - Fig. 4C and the two connection segment mode of Fig. 5A - Fig. 5D. What has been described above with reference to binding reference information serves as exemplary ways of implementing aspects of the present invention. Other binding information techniques are also within the scope of the
15 present invention, including those described in simultaneously-filed United States Patent Application Serial Number __/__, (attorney docket: 2380-187), entitled "Binding Information For Telecommunications Network", which is incorporated herein by reference in its entirety.

20 The present invention advantageously causes no disturbance to the connection segment involving the base station (such as base station 28₂₋₁ in the above described scenarios) upon performance of the SRNC relocation procedure, and minimizes or avoids any impact on call layer signaling. Moreover, the present invention allows an application in the drift RNC (DRNC) to allocate a diversity handling unit (DHO) resource at a time the SRNC relocation procedure is performed, and tear down the
25 connection segment over the Iur interface and a node internal connection (in the three connection segment mode), but keeping the connection segment between the drift RNC (DRNC) and the base station (e.g., base station 28₂₋₁).

30 While AAL2 signaling is normally utilized in the prior art to set up AAL2 connections end-to-end between devices, the present invention utilizes AAL2 signaling to setup connection or link segments (e.g., fragments) to connection/multiplexing points also.

Various aspects of ATM-based telecommunications are explained in the following: U.S. Patent Applications SN 09/188,101 [PCT/SE98/02325] and SN 09/188,265 [PCT/SE98/02326] entitled "Asynchronous Transfer Mode Switch"; U.S. Patent Application SN 09/188,102 [PCT/SE98/02249] entitled "Asynchronous Transfer Mode System", all of which are incorporated herein by reference. The present invention is not limited to ATM switch-based telecommunication nodes, but can be implemented with other types of protocols as well.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

09/188,101-04100